

TECHNICAL
SPECIFICATION

IEC
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SPÉCIFICATION
TECHNIQUE

TS 60479-2

Third edition
Troisième édition
2007-05

Effects of current on human beings and livestock –

**Part 2:
Special aspects**

**Effets du courant sur l'homme et
les animaux domestiques –**

**Partie 2:
Aspects particuliers**

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Reference number
Numéro de référence
IEC/CEI/TS 60479-2:2007



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CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Effects of alternating currents with frequencies above 100 Hz	10
4.1 General.....	10
4.2 Effects of alternating current in the frequency range above 100 Hz up to and including 1 000 Hz.....	10
4.2.1 Threshold of perception.....	10
4.2.2 Threshold of let-go	11
4.2.3 Threshold of ventricular fibrillation.....	11
4.3 Effects of alternating current in the frequency range above 1 000 Hz up to and including 10 000 Hz.....	12
4.3.1 Threshold of perception.....	12
4.3.2 Threshold of let-go	12
4.3.3 Threshold of ventricular fibrillation.....	12
4.4 Effects of alternating current in the frequency range above 10 000 Hz.....	13
4.4.1 Threshold of perception.....	13
4.4.2 Threshold of let-go	13
4.4.3 Threshold of ventricular fibrillation.....	13
4.4.4 Other effects.....	13
5 Effects of special waveforms of current	13
5.1 General.....	13
5.2 Equivalent magnitude, frequency and threshold.....	13
5.3 Effects of alternating current with d.c. components.....	14
5.3.1 Waveforms and frequencies and current thresholds.....	14
5.3.2 Threshold of startle reaction	15
5.3.3 Threshold of let-go	15
5.3.4 Threshold of ventricular fibrillation.....	16
6 Effects of alternating current with phase control	20
6.1 Waveforms and frequencies and current thresholds	20
6.2 Threshold of startle reaction and threshold of let-go	21
6.3 Threshold of ventricular fibrillation.....	22
6.3.1 Symmetrical control.....	22
6.3.2 Asymmetrical control	22
7 Effects of alternating current with multicyle control	22
7.1 Waveforms and frequencies	22
7.2 Threshold of startle reaction and threshold of let-go	23
7.3 Threshold of ventricular fibrillation.....	23
7.3.1 General	23
7.3.2 Shock durations exceeding 1,5 times the period of cardiac cycle.....	24
7.3.3 Shock durations less than 0,75 times the period of cardiac cycle.....	24
8 Estimation of the equivalent current threshold for mixed frequencies.....	24
8.1 Threshold of perception and let-go	24
8.2 Threshold of ventricular fibrillation.....	24

9	The effect of repeated pulses (bursts) of current on the threshold of ventricular fibrillation	25
9.1	Ventricular fibrillation threshold of multiple bursts of current separated by 1 s or more	25
9.2	Ventricular fibrillation threshold of multiple bursts of current separated by less than 1 s	25
9.2.1	General	25
9.2.2	Example 1	26
9.2.3	Example 2	28
10	Effects of electric current through the immersed human body	28
10.1	General	28
10.2	Resistivity of water solutions and of the human body	28
10.3	Conducted current through immersed body	30
10.4	Physiological effects of current through the immersed body	30
10.5	Threshold values of current	31
10.6	Intrinsically safe voltage values	32
11	Effects of unidirectional single impulse currents of short durations	32
11.1	General	32
11.2	Effects of unidirectional impulse currents of short duration	32
11.2.1	Waveforms	32
11.2.2	Determination of specific fibrillating energy F_e	33
11.3	Threshold of perception and threshold of pain for capacitor discharge	34
11.4	Threshold of ventricular fibrillation	35
11.4.1	General	35
11.4.2	Examples	36
	Bibliography	39
	Figure 1 – Variation of the threshold of perception within the frequency range 50/60 Hz to 1 000 Hz	10
	Figure 2 – Variation of the threshold of let-go within the frequency range 50/60 Hz to 1 000 Hz	11
	Figure 3 – Variation of the threshold of ventricular fibrillation within the frequency range 50/60 Hz to 1 000 Hz, shock durations longer than one heart period and longitudinal current paths through the trunk of the body	11
	Figure 4 – Variation of the threshold of perception within the frequency range 1 000 Hz to 10 000 Hz	12
	Figure 5 – Variation of the threshold of let-go within the frequency range 1 000 Hz to 10 000 Hz	12
	Figure 6 – Waveforms of currents	14
	Figure 7 – Let-go thresholds for men, women and children	15
	Figure 8 – 99,5 percentile Let-Go threshold for combinations of 50/60-Hz sinusoidal alternating current and direct current	16
	Figure 9 – Composite alternating and direct current with equivalent likelihood of ventricular fibrillation	18
	Figure 10a – Half wave rectification	19
	Figure 10b – Full wave rectification	19
	Figure 10 – Waveforms of rectified alternating currents	19
	Figure 11a – Symmetrical control	21

Figure 11b – Asymmetrical control	21
Figure 11 – Waveforms of alternating currents with phase control.....	21
Figure 12 – Waveforms of alternating currents with multicycle control.....	23
Figure 13 – Threshold of ventricular fibrillation (average value) for alternating current with multicycle control for various degrees of controls (results of experiments with young pigs).....	24
Figure 14 – Series of 4 rectangular pulses of unidirectional current.	26
Figure 15 – Series of 4 rectangular pulses of unidirectional current	27
Figure 16 – Series of 4 rectangular pulses of unidirectional current	27
Figure 17 – Forms of current for rectangular impulses, sinusoidal impulses and for capacitor discharges	33
Figure 18 – Rectangular impulse, sinusoidal impulse and capacitor discharge having the same specific fibrillating energy and the same shock-duration	34
Figure 19 – Threshold of perception and threshold of pain for the current resulting from the discharge of a capacitor (dry hands, large contact area)	35
Figure 20 – Threshold of ventricular fibrillation	36
Table 1 – Example of estimate for ventricular fibrillation threshold after each burst of current in a series.....	26
Table 2 – Resistivity of water solutions	29
Table 3 – Resistivity of human body tissues.....	29
Table 4 – Relative interaction between resistivity of water solution and the impedance characteristic of the electrical source.....	30

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –**Part 2: Special aspects**

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 60479-2, which is a technical specification, has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This third edition cancels and replaces the second edition, published in 1987, and constitutes a technical revision.

The major changes with regard to the previous edition are as follows:

- The report has been completed with additional information on effects of current passing through the human body for alternating sinusoidal current with d.c. components, alternating sinusoidal current with phase control, alternating sinusoidal current with multicycle control in the frequency range from 15 Hz up to 100 Hz.
- An estimation of the equivalent current threshold for mixed frequencies.
- The effect of repeated pulses (bursts) of current on the threshold of ventricular fibrillation.
- Effects of electric current through the immersed human body.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
64/1544/DTS	64/1579/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 60479 series, under the general title *Effects of current on human beings and livestock*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 2: Special aspects

1 Scope

IEC 60479-2, which is a technical specification, describes the effects on the human body when a sinusoidal alternating current in the frequency range above 100 Hz passes through it.

The effects of current passing through the human body for

- alternating sinusoidal current with d.c. components,
- alternating sinusoidal current with phase control,
- alternating sinusoidal current with multicycle control,

are given but are only deemed applicable for alternating current frequencies from 15 Hz up to 100 Hz.

NOTE 1 Other waveforms are under consideration.

This standard furthermore describes the effects of current passing through the human body in the form of single unidirectional rectangular impulses, sinusoidal impulses and impulses resulting from capacitor discharges.

NOTE 2 The effects of sequences of impulses are under consideration.

The values specified are deemed to be applicable for impulse durations from 0,1 ms up to and including 10 ms. For impulse durations greater than 10 ms, the values given in Figure 20 of IEC 60479-1 apply.

This standard only considers conducted current resulting from the direct application of a source of current to the body, as does IEC 60479-1 and IEC 60479-3. It does not consider current induced within the body caused by its exposure to an external electromagnetic field.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60479-1:2005, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC 60479-3, *Effects of current on human beings and livestock – Part 3: Effects of currents passing through the body of livestock*

IEC 60990, *Methods of measurement of touch current and protective conductor current*

3 Terms and definitions

For the purposes of this document, the following definitions, in addition to those given in IEC 60479-1, apply.

NOTE Certain definitions are taken from the IEC. Such references are listed in the bibliography [27], [28] 1).

**3.1
frequency factor**

F_f
ratio of the threshold current for the relevant physiological effects at the frequency f to the threshold current at 50/60 Hz

NOTE The frequency factor differs for perception, let-go and ventricular fibrillation.

**3.2
phase control**

process of varying the instant within the cycle at which current conduction in an electronic valve device or a valve arm begins

(IEV 551-16-23)

**3.3
phase control angle (current delay angle)**

time expressed in angular measure by which the starting instant of current conduction is delayed by phase control

(IEV 551-16-32)

**3.4
multicycle control**

process of varying the ratio of the number of cycles which include current conduction to the number of cycles in which no current conduction occurs

(IEV 551-16-31)

**3.5
multicycle control factor**

p
ratio between the number of conducting cycles and the sum of conducting and non-conducting cycles in the case of multicycle control

(IEV 551-16-37) (and see Figure 12 in this standard)

**3.6
specific fibrillating energy**

F_e (Ws/Ω or A²s)
minimum I^2t value of a unidirectional impulse of short duration which under given conditions (current-path, heart-phase) causes ventricular fibrillation with a certain probability

NOTE F_e is determined by the form of the impulse as the integral

$$\int_0^{t_i} i^2 dt$$

where t_i is defined in Figures 17 and 18. F_e multiplied by the body resistance gives the energy dissipated in the human body during the impulse.

**3.7
specific fibrillating charge**

F_q (C or As)
minimum $I-t$ value of unidirectional impulse of short duration which under given conditions (current-path, heart-phase) causes ventricular fibrillation with a certain probability

1) References in square brackets refer to the bibliography.

NOTE F_q is determined by the form of the impulse as the integral

$$\int_0^{t_i} idt$$

Where t_i is defined in Figures 17 and 18.

3.8 time constant

time required for the amplitude of an exponentially decaying quantity to decrease to

$$\frac{1}{e} = 0,3679$$

times an initial amplitude

(IEV 801-21-45, modified)

3.9 shock duration of a capacitor discharge

t_i

time interval from the beginning of the discharge to the time when the discharge current has fallen to 5% of its peak value (see Figures 17 and 18)

NOTE When the time constant of the capacitor discharge is given by T , the shock duration of the capacitor discharge is equal to $3T$. During the shock duration practically all the energy of the impulse is dissipated.

3.10 shock duration for complex asymptotic waveform

t_i

shortest duration of that part of the impulse that contains 95 % of the energy over the total impulse

3.11 threshold of perception

minimum value for the charge of electricity which under given conditions causes any sensation to the person through whom it is flowing

3.12 threshold of pain

minimum value for the charge ($I \cdot t$) or specific energy ($I^2 \cdot t$) that can be applied as an impulse to a person holding a large electrode in the hand without causing pain

3.13 pain

unpleasant experience such that it is not readily accepted a second time by the subject submitted to it

NOTE Example are an electric shock above the threshold of pain described in 11.3, the sting of a bee or burn of a cigarette.

4 Effects of alternating currents with frequencies above 100 Hz

NOTE Values for 50/60 Hz are given in IEC 60479-1.

4.1 General

Electric energy in the form of alternating current at frequencies higher than 50/60 Hz is increasingly used in modern electrical equipment, for example aircraft (400 Hz), power tools and electric welding (mostly up to 450 Hz), electrotherapy (using mostly 4 000 Hz to 5 000 Hz) and switching mode power supplies (20 kHz to 1 MHz).

Little experimental data is available for this clause, so that the information given herein should be considered as provisional only but may be used for the evaluation of risks in the frequency ranges concerned (see bibliography). Attention is also drawn to the fact that the impedance of human skin decreases approximately inversely proportional to the frequency for touch voltages in the order of some tens of volts, so that the skin impedance at 500 Hz is only about one-tenth of the skin impedance at 50 Hz and may be neglected in many cases. This impedance of the human body at such frequencies is therefore reduced to its internal impedance Z_i (see IEC 60479-1).

NOTE **The use of peak measurements.** At current levels that produce physiological responses of perception, startle reaction and inability of let-go, the physiological response from non sinusoidal and mixed frequency periodic current is best indicated by the peak value of an output signal from measuring circuits containing a frequency-weighting network such as those described in IEC 60990.

These frequency weighting networks attenuate the signal according to the frequency factors of Clause 4 of IEC 60479-1 so that the output signal corresponds to a constant level of physiological response. Attenuation is provided for narrow impulses of current that would produce less physiological response because of the short duration of their peak value. The network output allows a fixed value to be read independent of waveshape or mix of frequencies to be provided for ease of determination of the leakage current and evaluation of the level of hazard present.

Comparable physiological effects are produced by non sinusoidal and sinusoidal current producing the same peak value by this measurement method.

Representative network can be found in IEC 60990 and in bibliographic reference [16].

4.2 Effects of alternating current in the frequency range above 100 Hz up to and including 1 000 Hz

4.2.1 Threshold of perception

For the threshold of perception the frequency factor is given in Figure 1.

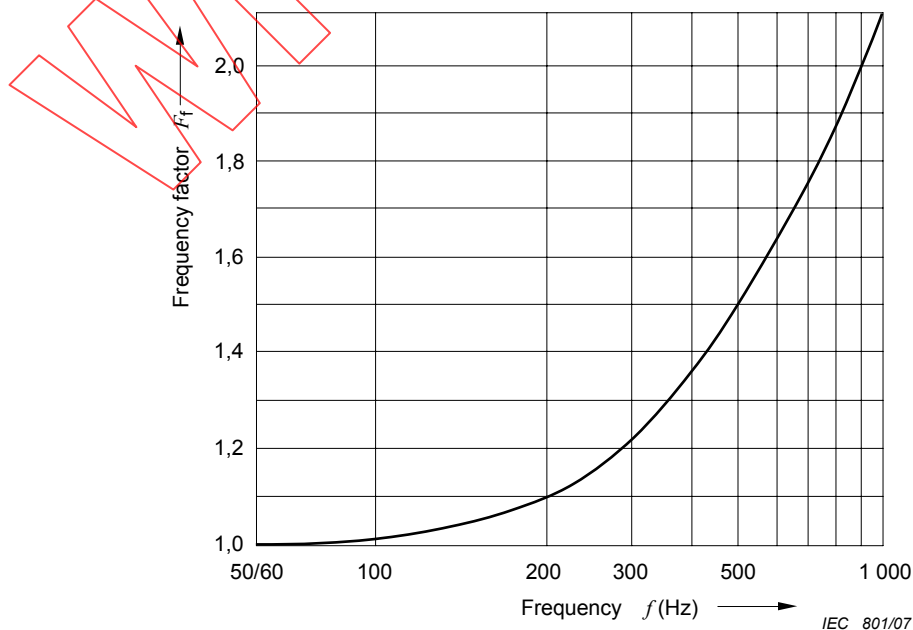


Figure 1 – Variation of the threshold of perception within the frequency range 50/60 Hz to 1 000 Hz

4.2.2 Threshold of let-go

For the threshold of let-go the frequency factor is given in Figure 2.

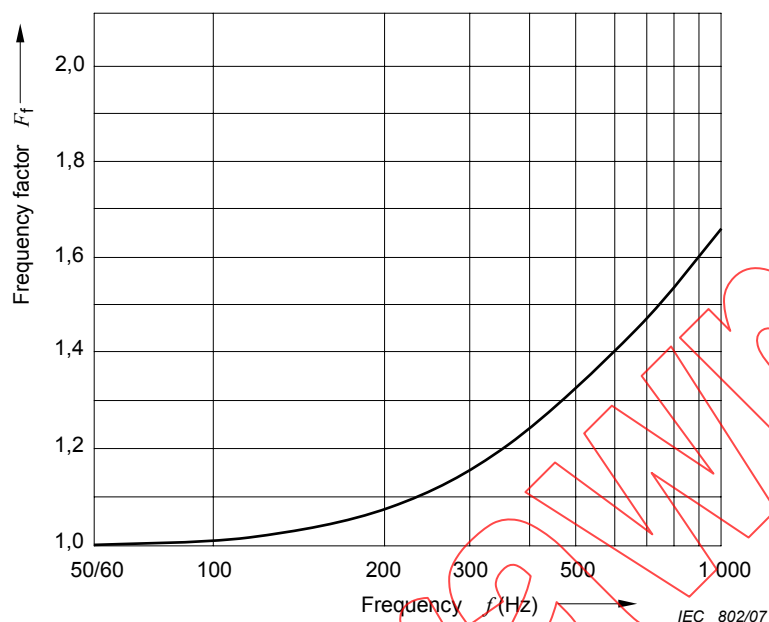


Figure 2 – Variation of the threshold of let-go within the frequency range 50/60 Hz to 1 000 Hz

4.2.3 Threshold of ventricular fibrillation

For shock durations longer than the cardiac cycle, the frequency factor for the threshold of fibrillation for longitudinal current paths through the trunk of the body is given in Figure 3.

<https://standards.iteh.ai/>

[https://](https://standards.iteh.ai/) For shock durations shorter than the cardiac cycle no experimental data is available. [ts-60479-2-2007](https://standards.iteh.ai/)

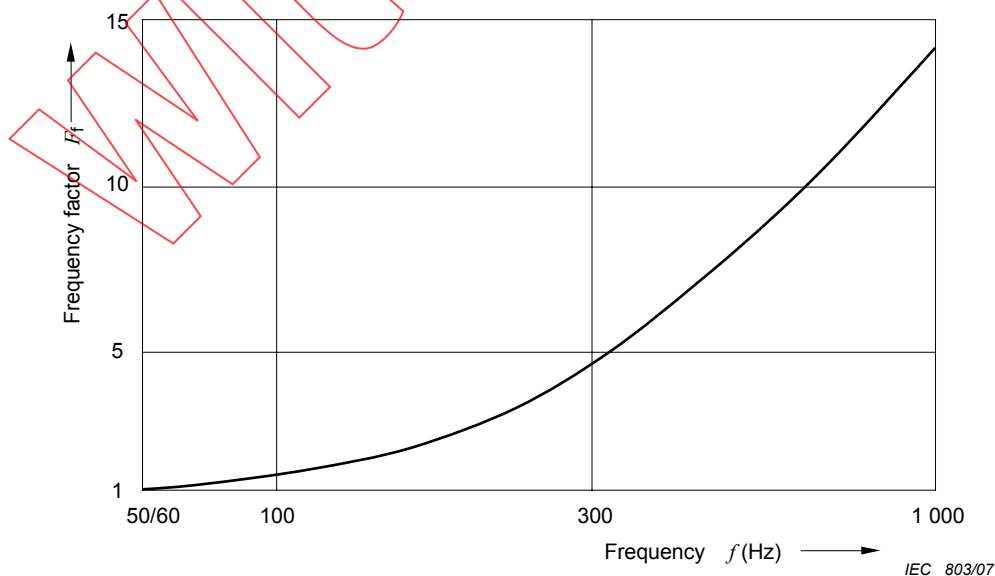


Figure 3 – Variation of the threshold of ventricular fibrillation within the frequency range 50/60 Hz to 1 000 Hz, shock durations longer than one heart period and longitudinal current paths through the trunk of the body

4.3 Effects of alternating current in the frequency range above 1 000 Hz up to and including 10 000 Hz

4.3.1 Threshold of perception

For the threshold of perception the frequency factor is given in Figure 4.

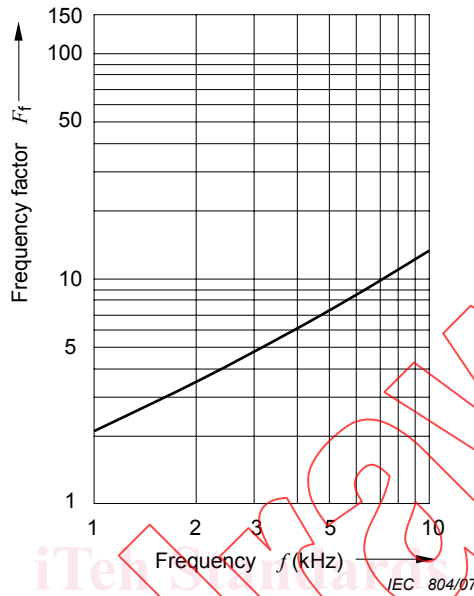


Figure 4 – Variation of the threshold of perception within the frequency range 1 000 Hz to 10 000 Hz

4.3.2 Threshold of let-go

For the threshold of let-go the frequency factor is given in Figure 5.

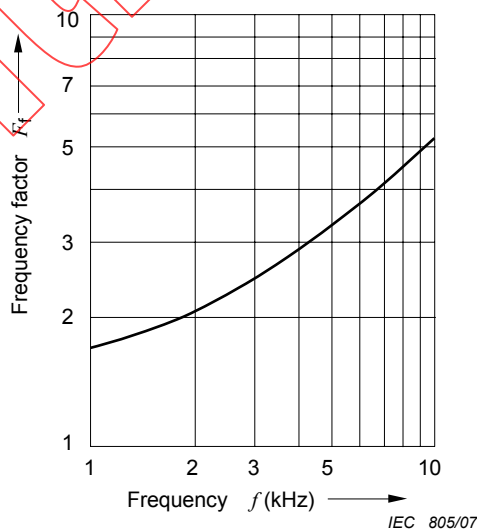


Figure 5 – Variation of the threshold of let-go within the frequency range 1 000 Hz to 10 000 Hz

4.3.3 Threshold of ventricular fibrillation

Under consideration.